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Medical Research Council
War Memorandum No. 15

THE STERILIZATION, USE AND CARE OF SYRINGES

by

A COMMITTEE APPOINTED BY THE MEDICAL RESEARCH
COUNCIL



LONDON

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COMMITTEE ON THE STERILIZATION OF SYRINGES

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THE STERILIZATION, USE AND CARE OF SYRINGES

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I. INTRODUCTION

Mild inflammations and infections following prophylactic inoculation and other types of injection are not uncommon. Abscesses and severe infections sometimes develop, and may occasionally be fatal. It is usually possible to trace a severe infection due to this cause to some technical fault which might have been avoided by the exercise of sufficient care. Any risk, however small, will produce accidents if it is repeated often enough.

Accidents following injection are especially serious when they occur in the course of mass inoculations or hospital practice. Conditions attributable to faulty injection technique have included many instances of streptococcal cellulitis and lymphadenitis; staphylococcal and streptococcal abscesses and local skin lesions (Allison, 1938); tuberculosis (Bigger, Blacklock and Parish, 1940); meningitis due to contaminated lumbar puncture needles (Smith and Smith, 1941); anaerobic infections such as tetanus (Osburne, 1892; Siegert, 1901; Simpson, 1907; Bulloch, 1929) and gas gangrene (Junghanns, 1933; Touraine, 1936); systemic diseases like infective hepatitis following the injection of arsenic for syphilis (Bigger, 1943; Sheehan, 1944; Salaman, King, Williams and Nicol, 1944), of bismuth for syphilis (Kulchar and Reynolds, 1942), of gold for rheumatoid arthritis (Hartfall, Garland and Goldie, 1937), and the use of syringes that have been contaminated with blood withdrawn for sedimentation tests (Sheehan, 1944); and malaria (Wenyon, 1926).

In hospitals entirely safe methods are easily practicable, and ought to be used. All medical students and nurses must be taught such methods, and must learn to expect them in hospitals. They must, for example, expect syringes used in wards to be sterilized in the hot air oven or autoclave rather than boiled; and they must know the risks that attend careless and imperfect technique.

It is the object of this memorandum to provide a small handbook for teachers, and for all who use syringes for injection or aspiration. The recommendations made are based on the experience of many workers, and on bacteriological tests; they have been proved to be safe and practicable.

The technique for mass inoculation described has been extensively used, and remains the safest practical method so far devised. The risk that, in changing needles, the syringe nozzle may become contaminated, which has been revealed since this Memorandum was written (Hughes, 1946, a, b), is greatest for intravenous and intramuscular injections. Until some practicable technique has been devised and tested to overcome it, the risk must be accepted: it should, however, be recognized.

II. THE SOURCES AND AVOIDANCE OF INFECTION FOLLOWING INJECTIONS

A. THE USE OF NON-STERILE SYRINGES AND NEEDLES

1. *Meaning of the word "sterile".*—Complete bacteriological sterility can be achieved only by sterilization in the autoclave or hot air oven. Boiling in water will destroy all pathogenic bacteria except those that produce resistant spores. Boiling in water to which a little sodium carbonate has been added will kill spores as well as non-sporing bacteria, but cannot be recommended as a method for sterilizing syringes, because the residual alkalinity of the syringe may destroy certain of the drugs and biological products to be injected. Chemical disinfectants, including alcohol (see p. 12), if they kill spores at all, do so very slowly, and cannot always be relied upon to destroy even non-sporing bacteria in syringes.

The word "sterile", therefore, applied to a syringe and needle, implies that the syringe and needle have been through the process of sterilization in the autoclave or hot air oven. It is often loosely applied to a syringe that has been boiled. Since accidents due to spore-bearing bacteria have proved rare, a boiled syringe may be accepted as reasonably safe where sterilization in the autoclave or hot air oven is impracticable, but a boiled syringe is not necessarily sterile, and its safety cannot be absolutely guaranteed.

2. *Failure to clean and sterilize syringes and needles after use* (see p. 8).—A fresh sterile syringe and needle must be used for each injection or aspiration. In clinics where many injections of the same fluid are given, the same syringe may be used for several consecutive subcutaneous or intramuscular—but not intravenous—injections, provided that a fresh needle is used for each patient.

A syringe that has been used for aspiration, e.g., of blood from a vein, or pus from an abscess, or for intravenous injection, which always entails aspiration of blood, must be cleaned and sterilized before it is used again. **It is essential to keep syringes for injection separate from those used for aspiration.**

Syringes and needles require thorough cleaning after use, before re-sterilization. Sterilization methods may be unreliable if the syringe or needle contains dirt or coagulable protein.

Needles must be kept sharp. Instructions for sharpening needles are given in Section X, p. 17.

3. *Contamination of syringes and needles during assembly after sterilization, due to contact with fingers, dust, or droplets of saliva from either the doctor or the subject, or to contact of the needle with a non-sterile surface.*—Handle needles with sterile forceps only, syringes with dry, washed hands, taking care to touch only the outside of the barrel and the handle of the piston. Do not talk, cough or sneeze over a sterile syringe. Do not allow a sterile needle to touch any unsterilized surface or object before use.

Persons with known or suspected upper respiratory infections must wear impervious masks while carrying out inoculations or injections.

The operator and all assistants must wash their hands thoroughly with soap and warm water and dry them on a clean towel before commencing work, and at intervals during prolonged operations. As an extra precaution during mass inoculations, or if there is reason to think that the operator's hands are infected, the hands may be steeped in some suitable disinfectant, such as hypochlorite solution containing at least 0.1 per cent. of free chlorine.*

Use of a pocket handkerchief must at once be followed by a thorough hand washing.

The practice of "dishing up" a sterile syringe and needle in an open bowl, especially one which contains any liquid, is to be unreservedly condemned. Sterile syringes and needles must be placed in sterile covered containers (see pp. 11-12).

4. *Rinsing the sterile syringe in contaminated "sterile" water or saline.*—Use dry-sterilized syringes whenever possible. If wet-sterilized syringes are used, and need rinsing in sterile saline, the saline for the purpose must be taken directly from a previously unopened, autoclaved bottle. After opening, the saline bottle must be discarded, and not kept for future use. To remove the risk that saline bottles, once opened, will be kept and used again, it is advisable to have saline autoclaved in small quantities, say 10 or 20 ml., for the purpose of rinsing syringes.

* The following four preparations all contain between 9 and 12 per cent. of free chlorine and are suitable disinfectants for hands if used in 1 per cent. solution: Deosan (Deosan, Ltd., 345, Gray's Inn Road, London, W.C.1); Chloros (I.C.I. (General Chemicals), Ltd., Cunard Buildings, Liverpool); Dairozon (B. Laporte, Ltd., Luton, Beds.); Hyposan (Voxsan, Ltd., 23, Church Street North, West Ham, London, E.15). See Ministry of Health Circular 2819 (England), May, 1943.

5. *Intrathecal aspirations and injections.*—Needles, syringes and manometers for intrathecal work need specially careful sterilization. Hot air sterilization should be used when practicable; otherwise, sterilize by autoclaving or by boiling for five minutes.

B. CONTAMINATION OF INJECTION FLUIDS

One of the best known accidents due to the contamination of an injection fluid was the Bundaberg disaster, in which diphtheria prophylactic was contaminated with a highly pathogenic staphylococcus (Report, 1928).

Vaccines, diphtheria toxoid, and other prophylactic agents which contain a disinfectant such as phenol, are commonly dispensed in rubber-capped bottles. These may be kept for repeated use provided that due care is taken to sterilize the cap each time before puncturing it, and to preserve its integrity.

As far as possible, for isolated injections at intervals, single dose containers should be used.

A very satisfactory pattern of vaccine bottle, which may be warmly recommended, is that described by Berry (1938)* and illustrated in Figure 1. The skirted rubber vaccine cap which closes the bottle is protected by an outer Bakelite screw cap containing an absorbent pad which can be impregnated

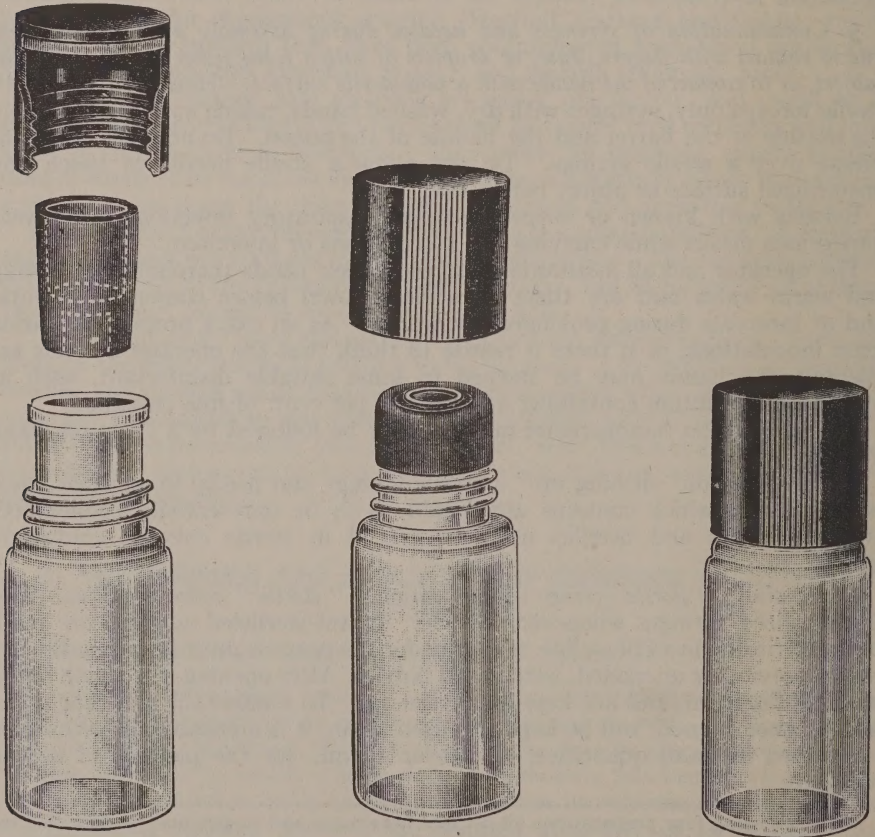


FIG. 1.—Rubber-capped vaccine bottle and bakelite dome cap (Berry, 1938). Reproduced, by permission, from the *Pharmaceutical Journal*.

* Makers: Messrs. Britton Malcolm & Co., Southwark Bridge Road, London, S.E.

with a 10 per cent. solution of chloroxylenol B.P. Provided that the pad is kept well wetted with the solution of chloroxylenol, the skirted rubber cap beneath it will remain always sterile, and will require no further treatment before puncturing.

Older patterns of vaccine bottle have rubber caps which are unprotected, and which must be sterilized before puncturing. The best way to sterilize them is to wipe them with a clean lint swab dipped in tincture of iodine or 75 per cent. v/v alcohol.

When they are not in use, vaccine bottles should be replaced in their cardboard containers, to protect them from dust, and from light, which may cause deterioration of the product.

A fresh sterile needle must be used every time a rubber cap is punctured. It is unwise to puncture one cap too frequently, because small leaks may then develop through which contamination can enter.

Whenever possible, injection fluids in their containers should be stored in the refrigerator at as low a temperature as possible above freezing point. Temperatures below freezing point should be avoided, since undesirable changes may occur in some types of biological reagent.

C. FAILURE TO CLEANSE THE SKIN AT THE SITE OF INJECTION

To cleanse the skin before the injection, rub the selected inoculation site with a small quantity of spirit or tincture of iodine on a lint swab, and allow to dry.

III. THE CHOICE OF SYRINGES AND NEEDLES

All-glass syringes should be of good quality, and preferably should comply with a rigid specification such as that issued by the British Standards Institution for "All-glass Hypodermic Syringes", No. B.S. 1263 (1945). (Obtainable from British Standards Institution, 28, Victoria Street, London, S.W.1.) This specification has been specially compiled for syringes to be used in accordance with the instructions set out in this memorandum.

Stainless steel used for needles should be of best quality; it should combine flexibility and strength, and should be highly resistant to corrosion and tarnishing.

All-glass syringes are easier to clean and sterilize than are those made of glass and metal. They are less likely to break on heating, and they have no cement to melt in the oven or autoclave. If properly cleaned and lubricated, they may be assembled before sterilization.

The only advantage of the glass-metal syringe is its less fragile nozzle. It is more difficult to clean, and it is apt to break on heating, because of the unequal expansion of the glass and metal; moreover, the cement may melt in the hot air oven and even in the autoclave. After boiling, glass-metal syringes take longer to cool than do those made entirely of glass. Glass-metal syringes cannot be sterilized assembled.

IV. INSTRUCTIONS FOR STERILIZING ALL-GLASS SYRINGES

NEW SYRINGES

Before use, new syringes should be well washed in soap and water, using a test-tube brush or burette brush for the barrel, according to size. Both piston and barrel are rinsed in clean water and dried with a fluffless cloth.

The piston is lightly smeared with liquid paraffin, by dipping the tip only of the piston into liquid paraffin contained in a wide-mouthed screw-capped 2 oz. bottle or jar, and rubbing the paraffin well into the ground surface with the finger. Excess of liquid paraffin must be avoided.

The piston is inserted into the barrel and worked backwards and forwards several times to ensure proper lubrication, and to make sure that the syringe is working smoothly and evenly.

The assembled syringe is placed in a glass tube of such diameter that the barrel of the syringe is a loose fit, but that the flange rests on the top of the tube (see Figure 2). The tube should be long enough to take the syringe when a needle is attached, without the point of the needle touching the bottom of the tube. (For sterilization of needles, see pp. 9, 13.)

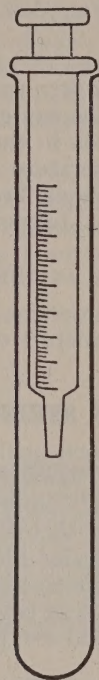


FIG. 2.—Method of suspending a syringe in a test-tube prior to sterilization.

The tube with syringe in position is wrapped in kraft paper. The paper is turned over and inwards at the bottom of the tube and twisted spirally round the tube, ending in a firm twist of paper at the top of the piston. Relevant details, such as capacity of syringe, name of ward, date and worker's initials are now written with lead pencil on the paper. The wrapped syringe is sterilized in the hot air oven as detailed below. Alternatively, the syringe and tube may be wrapped in "Cellophane"*, when the details of the syringe are clearly seen through the wrapper. Sterilization in the hot air oven causes the "Cellophane" to turn slightly brown, which is an indication that the syringe has been subjected to heat treatment.

INFECTED SYRINGES

When syringes are used for blood culture, or for aspirating infected material, some antiseptic should be used when washing them out.

After blood, etc., has been withdrawn and expelled into the specimen container or blood culture bottle, the syringe is immediately washed with a cold solution of 2 per cent. lysol (contained in a small enamelled dish), by sucking up and expelling the fluid several times, with the needles till in position. The

*Special stout "Cellophane" envelopes are obtainable for this purpose (McCartney, 1951).

lysol solution must be colder than tepid. Hot fluid will coagulate protein, and the syringe will then stick. It is emphasized that the syringe must be washed out immediately after the blood is expelled, and before remaining blood can clot.

After being washed out with lysol, the syringe, with the needle still in position, is replaced in its glass tube. If the needle is removed before the blood or pus is expelled from the syringe, it should be placed in 2 per cent. lysol; the syringe is immediately washed out as above, and the needle withdrawn from the lysol with forceps and fixed to the syringe, which is again washed out in order to clear the needle.

When non-infective material is used, e.g., biological reagents, dextrose solution, drugs, etc., the syringe may be washed out as above with *cold* water. Syringes used, however, for the administration of antitoxin should be treated like infected syringes; antitoxin sticks firmly to the ground surface of the piston and other irregularities in the glass, and its removal is facilitated by the use of lysol. After washing, syringe and needle are returned to the tube in which they were sterilized.

CLEANING

Before being re-sterilized, the syringe must be thoroughly cleaned by being washed in warm soapy water, using a test-tube brush or burette brush for the barrel. Antitoxin tends to adhere to the side of the barrel and must be removed from the flat end at the nozzle, so as to prevent the syringe from sticking when re-sterilized. After being rinsed in warm water, piston and barrel are dried with a soft clean cloth, care being taken that no threads or fluff are left; otherwise the syringe will not work smoothly. The cleaning technique is the same as that described for new syringes. The piston is lightly lubricated with liquid paraffin, which is well rubbed in with the finger. The syringe is then re-assembled, placed in its tube, wrapped in kraft paper, and relevant details are written thereon.

If several syringes of the same capacity are being cleaned at the same time, it is essential to see that each piston is inserted into the barrel belonging to it. An identification number should be engraved on the piston and barrel of every syringe, to ensure that the correct parts are fitted.

STERILIZING

The assembled and wrapped syringes are placed in the *hot air* sterilizer and maintained at 160°C . *for not less than one hour*. The sterilizer must have a reliable thermostatic control, and be provided with a thermometer, the bulb of which is near the syringes. The temperature must be checked from time to time, to ensure that effective sterilization is carried out. Control tests with infected material containing spores should be made, and the whole process of sterilization should be under expert bacteriological control.

Syringes and needles are placed in the oven while it is cold; the time of sterilization is not less than one hour after 160°C . has been reached. The oven should be allowed to cool before the syringes and needles are removed.

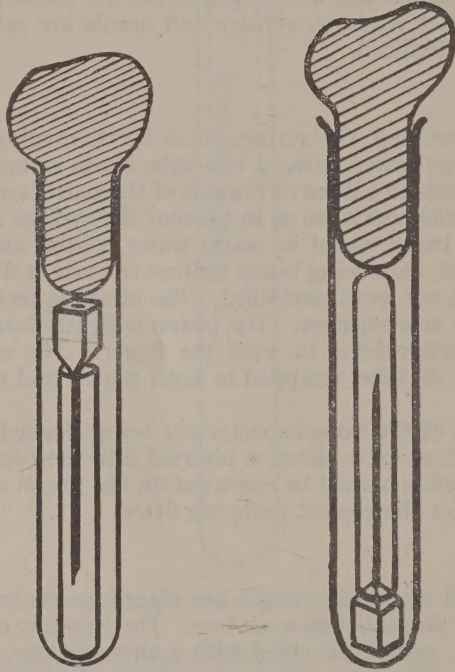
If syringes and needles are sterilized by autoclaving, a temperature of 120°C . (15 to 20 lb. pressure) must be maintained for 20 minutes (see *M.R.C. War Memorandum No. 6*). Packing should be as for hot air sterilization.

NEEDLES

When the syringe is cleaned, the needle is detached and well washed through with warm water from a small (2 ml.) syringe, which may be kept for this purpose if a number of needles are used. The mount of the needle is cleaned out with a piece of cotton wool on the end of a swab stick, to remove any blood, etc. The needle is then washed through again, first with water and then

with alcohol (industrial methylated spirit), and allowed to dry. Drying may be hastened by placing the needle on a warm radiator or a hot plate.

The point of the needle is touched up on a fine Arkansas slipstone (size 4 in. $\times$ 1 $\frac{1}{4}$ in.), lubricated with liquid paraffin or thin machine oil (see p. 17). The point should be examined under a hand lens (8x) (see Fig. 7). If it is satisfactory, the needle is washed again thoroughly in spirit and dried. The wire stilette, lubricated with a very small quantity of liquid paraffin, is passed through the bore to make sure that it is patent. The clean needle is finally inserted into a piece of 5 mm. bore glass tubing, 2 inches long, and placed in a 3 in. $\times$ $\frac{1}{2}$ in. test tube (see Figure 3), which is plugged with a twist of kraft paper or a piece of gauze (if cotton wool is used, threads may adhere to the needle mount). The plug is forced down the tube, to hold the needle firmly and prevent it from moving.



FIGS. 3 and 4.—Alternative methods of inserting a needle into glass tubing, used as a guard, prior to sterilization.

Alternatively, the needle may be placed in its tube as shown in Fig. 4. Here the mount of the needle rests on the bottom of the tube and there is no liability for strands of cotton wool, if this material is used for the plug, to enter it.

The tube and needle are then wrapped in a piece of kraft paper, and details of the length of needle, bore, ward, date, etc., written on the paper with lead pencil.

If "Cellophane" is used, the relevant details may be written on a small piece of gummed paper which is affixed to the tube. The writing is easily read through the transparent wrapping.

The wrapped needles are sterilized in the hot air oven with the syringes for one hour at 160°C.

The syringe and needle are assembled immediately before use, as follows:—

The kraft paper of the syringe tube is untwisted until the end of the piston and flange (neck; rim) of the barrel are exposed. The syringe is withdrawn

from the tube by grasping the flange. The needle tube is also unwrapped, the plug removed without touching the lip of the tube, and the nozzle of the syringe applied to the tube. Both tube and syringe are inverted together, so that the mount of the needle slips on to the nozzle. The needle is secured tightly with a pair of sterile forceps and not with the fingers. The syringe is now ready for use.

If the needle has been put up in its tube as shown in Fig. 4, the needle tube is unwrapped and the plug removed. The test-tube is tilted until the glass tubing holding the needle begins to slide out, when it is gripped by the left hand. The test-tube and glass tubing are now completely inverted, so that the hub of the needle is uppermost. The test-tube is withdrawn, and the nozzle of the syringe inserted downwards into the needle mount and pressed home. The piece of glass tubing is then removed, and the needle tightened into position on the syringe with the sterile forceps.

Many workers may prefer syringes and needles to be assembled before sterilization.

V. DISINFECTION OF SYRINGES BY BOILING

If an autoclave or hot air oven is not available, or if glass-metal syringes are to be used, "sterilization" by boiling in water is the method of choice, although, as explained above (p. 4), boiling cannot be relied on to destroy all spores. The addition of a little sodium carbonate to the water in which a syringe is boiled will ensure the destruction of spores, but this practice is not to be recommended, because the resulting alkalinity of the syringe may affect drugs or biological products to be injected.

Syringes should be thoroughly washed before they are boiled; boiling will coagulate and fix any protein left in them.

The sterilizer.—Commercial sterilizers are usually provided with a close-fitting lid, and have a perforated tray inside. A saucepan with a lid is a satisfactory *extempore* sterilizer.

A piece of lint fastened to the tray of the sterilizer may protect the needle points during boiling, and prevent the syringe parts from moving about and hitting one another.

The sterilizer may be heated on a spirit lamp, or on a gas ring or hot plate. Electric sterilizers, though expensive, are very satisfactory.

The water.—In districts where the water is hard, a film of chalk will collect on the syringe if it is boiled in tap water. Syringes coated with chalk are difficult to assemble, and soon become worn. Deposition of chalk can be prevented by the use of distilled water, rain water or softened water. Chalk deposit can be dissolved off all-glass syringes with weak hydrochloric acid. The deposition of chalk from tap water may be prevented by the addition of a small quantity of sodium hexametaphosphate to the water; but as this substance may precipitate alkaloidal solutions and, by combining with protein, may affect serum reactions, it is not to be recommended for general use.

Procedure.—The piston and barrel of the syringe, the needle and a pair of dissecting forceps are placed separately in cold or warm water (not above 50° C.) in the sterilizer. Syringes should not be dropped straight into water which is already boiling, or they may break.

The water is brought to the boil, and kept boiling for not less than *five minutes*. The lid of the sterilizer is then removed, and inverted on the table. The tray containing the syringes and needles is lifted out and placed in the lid by means of two pairs of sterile (flamed or boiled) forceps or, failing forceps, with clean dry fingers, provided, however, that the handles of the tray are above water level. The water in the sterilizer is poured away, the tray at once returned to the sterilizer, and the cover immediately replaced.

When the syringe is reasonably cool and dry, the barrel and piston are assembled with the aid of sterile forceps, or with clean dry fingers, care being taken to touch only the outside of the barrel and the head of the piston. The needle should be fixed to the barrel by means of the sterile forceps, and should not be touched with the fingers.

After assembly, the syringe should be returned to the empty sterilizer and covered with the lid until it is used. It should not be dish up in any other container, unless this is covered and has been previously sterilized; neither should it be transferred to alcohol.

If an instrument sterilizer is not available, the syringe should be boiled in a saucepan fitted with a lid. After boiling, the water is poured off gently, the lid being held to retain the syringe inside. The saucepan should then be left covered till the syringe parts are cool enough to assemble. If this method is used, it is an advantage to thread the needle through a piece of lint, to afford some protection to the point.

From start to finish, the boiling and assembly of a syringe need not occupy more than ten minutes.

On wrapping syringes in lint during their sterilization by boiling.—It is sometimes suggested that the separate parts of syringes should be wrapped in lint before boiling, in order to prevent them from bumping against one another and getting mixed. This practice is not, however, recommended, partly because syringes so treated do not dry when the water is poured away after boiling and so have to be handled wet, and partly because it is not certain that the temperature of a syringe wrapped in lint reaches the boiling point of water.

VI. DISINFECTION OF SYRINGES BY MEANS OF ALCOHOL AND OTHER CHEMICAL DISINFECTANTS

Spirit is used more often than any other chemical disinfectant for sterilizing syringes. After careful deliberation, it has been decided that this practice cannot be recommended except with reservations which largely deprive it of its convenience. In arriving at this important conclusion, members of the Committee responsible for this memorandum thought it well to review existing knowledge of the disinfectant action of alcohol, and to make certain experiments to fill gaps in this knowledge, particularly with regard to the sterilization of syringes. Appendix A (p. 19) gives a brief summary of the literature on the subject, and includes a short account of some of the experiments made by members of the Committee.

Chemical disinfectants in general have the following disadvantages :—

- (1) Their germicidal action is often slow and may not be complete for a considerable time.
- (2) They cannot be guaranteed to penetrate into the crevices and corners of a syringe in which bacteria may lodge.
- (3) They may damage or destroy the material to be injected, e.g., Dick toxin by alcohol, hormone products and various drugs by traces of alkali.
- (4) With many of them, dilution, as with the water in a recently washed syringe, may seriously impair their disinfectant action.

Taking all these considerations into account, the Committee make the following recommendations :—

- (1) The only chemical disinfectant that can be in any way recommended for syringe disinfection is 70–75 per cent. v/v alcohol. Hypochlorites, phenols, chlorophenols, quaternary ammonium salts and detergents have been found ineffective as disinfectants for syringes, and may

damage the material to be injected. It is not implied that these disinfectants are intrinsically inefficient, but simply that they cannot overcome the peculiar obstacles which impede the disinfection of a syringe.

- (2) The common practice of attempting to disinfect a syringe by alternately filling it with spirit and discharging is to be condemned; it will not disinfect either an all-glass or a glass-metal syringe.
- (3) With *all-glass* syringes, immersion of the separate parts—barrel, piston and needle—in freshly prepared 70–75 per cent. v/v alcohol for at least five minutes is satisfactory for destroying vegetative bacteria, but not spores. Glass-metal syringes cannot be disinfected with certainty by this method.
- (4) The Committee consider it justifiable to disinfect syringes with alcohol only when they are used for no other purpose than the injection of a sterile fluid, such as insulin, in circumstances such that sterilization by heat is impracticable. Syringes used for aspiration and for venepuncture, and all syringes used in hospitals and clinics and for mass inoculations, should be sterilized by heat.
- (5) If, in the circumstances defined above, alcohol is used for disinfection, all-glass syringes alone should be employed. Before immersion in the alcohol, the syringe should be washed clean in tap water, if necessary with the aid of a test-tube or burette brush. The alcohol should be freshly taken from a stoppered bottle, and should not be used for more than a few times in succession. The correct strength of alcohol to use is 70–75 per cent. by volume; this can be prepared by diluting four parts of industrial methylated spirit with not more than one part of water. It is safer to use alcohol that is too strong rather than too dilute, but it should be remembered that above 75 per cent. the disinfectant action of alcohol on a dry surface decreases rapidly. The needle should be attached to the washed syringe, and spirit sucked up and down two or three times so as to wet the interior of the needle thoroughly. The syringe should then be dismantled, and the separate parts, together with the needle, completely immersed in the spirit, in a suitably covered vessel, for at least five minutes. The barrel and piston should then be lifted from the spirit by means of clean forceps which have, themselves, been half immersed in the spirit for a similar time, or, preferably, sterilized in a spirit flame. Excess alcohol having been shaken off, the barrel and piston may be assembled with clean dry fingers. The needle is then taken from the spirit and fixed to the barrel by means of the forceps. If it is necessary to wash the spirit out of the syringe with sterile water or saline, the precautions described on p. 5 should be observed.

After disinfection by this method, the syringe should be placed in a sterile test-tube or covered container until it is used.

VII. DISINFECTION BY THE HOT OIL METHOD

Sterilization by means of hot oil, as recommended in *M.R.C. War Memorandum No. 6*, has been tested by members of the Committee preparing the present memorandum, and has been found unsatisfactory for sterilizing syringes. Even vegetative organisms dried on to the glass are not uniformly destroyed. The method can be used successfully for the sterilization of needles, provided that the needles are left for an adequate time in the hot oil. They may be stored in the oil in which they have been heated.

VIII. MASS INOCULATIONS

The correct use of syringe and needle is the central act of mass inoculation technique, around which the rest of the procedure should be planned. For this reason, the following account, which is based on the experience of several mass inoculation teams, is given at length.

THE TEAM

If one dose of one preparation is to be given to the subjects, the optimal number of persons in the team is four—one, who should be medically qualified, to give the injections, an assistant to look after and fill syringes, another (often a nurse) to cleanse the skin of the subjects before injection, and a fourth to marshal the subjects and keep the records.

If two injections are to be made, as for example in combined active and passive immunization, or in Schick testing, it is an advantage to have two doctors giving the two injections simultaneously, each having an assistant to fill syringes for him. By this means, risk of confusing the two injection fluids or syringes is minimized. Otherwise, no appreciable increase in speed is attained by adding to the team. If it is necessary to inoculate a larger number of subjects in a given time, another complete team with apparatus should be enlisted.

RECORDS

Record keeping is best done on individual cards or slips of paper, on which are written the name of the school or institution, the surname (in block letters), christian name, age and sex of each subject. Cards should be filled in by the school or institution authorities beforehand, and distributed to the subjects on the day of inoculation.

Subjects enter the room in which inoculations are to be made with their sleeves rolled up. Near the entrance, they give up their cards to the assistant, who stamps the cards immediately with the date and details of inoculation, or collects them for completion later. Another assistant then swabs the selected inoculation site with spirit, tincture of iodine or other chosen disinfectant, and the subject passes along to be inoculated.

SYRINGES AND NEEDLES

Either of two procedures is possible, depending on facilities for sterilization.

1. *Syringes sterilized by hot air, needles by boiling.*—Syringes are brought ready sterilized and packed in test-tubes (see p. 8). Four syringes and at least eight needles are needed, together with a shallow oblong instrument sterilizer, containing distilled water kept gently boiling by means of a spirit lamp or other suitable burner. Two pairs of forceps are partly immersed in the boiling water.

Three of the syringes are needed to maintain a rotation, one being in use while a second lies ready for use, and the third is having its needle changed. The fourth syringe is used, not for inoculation, but for washing used needles with distilled water before re-sterilizing them.

After each injection, the syringe, with its needle still attached, is deposited on a rest or in a test-tube, from which the assistant takes it to change the needle. He removes the needle, and washes it through with distilled water by means of the fourth syringe. He then places the needle in one of eight places arbitrarily fixed in an elliptical pattern in the sterilizer. The used needle is put in the vacant place first reached, reckoning clockwise, in the gap in the ellipse caused by the fact that three needles will, at any one time, be fitted to syringes. The next needle in a clockwise direction is then removed with forceps and fitted

to the syringe, which is finally deposited, after filling, on a second rest or, better, in a second test-tube, ready to the hand of the doctor giving the injections. This arrangement ensures that each needle will have the maximum available time in the sterilizer.

Using such a method, it is possible to give 400 injections per hour. This gives an absolute minimum of 30 seconds for each needle in the sterilizer. Experiments have indicated that this time is long enough to kill pyogenic cocci on clean needles (Wells, 1944).

A piece of lint should be fixed to the perforated tray in the sterilizer, to prevent displacement of needles by currents in the boiling water, and to protect their points. It is important to see that the distilled water in the sterilizer does not boil away to a depth of less than three-quarters of an inch before being replenished. If attention is given to this point, the temperature anywhere in the water has not been observed to fall below 87°C .

2. *Syringes and needles both sterilized with hot air.*—This is the safest method, and the quickest and easiest in practice. It depends on access to hot air sterilization facilities, and on the possession of a large number of needles, so that sufficient to allow one needle for each injection may be taken ready sterilized to the school or clinic.

All-glass syringes should be packed as described above (p. 8), and sterilized in the hot air oven. One syringe can be used for many injections—other than intravenous—provided that a fresh sterile needle is used for each. It is advisable to have one or two spare sterile syringes available, in case one becomes soiled or broken accidentally.

Needles may be packed individually, as described on p. 10, or they may be packed in containers like that illustrated in Figure 5. In this container, each needle rests, point downwards, in a small $5 \times 40\text{ mm}$. glass tube, the glass

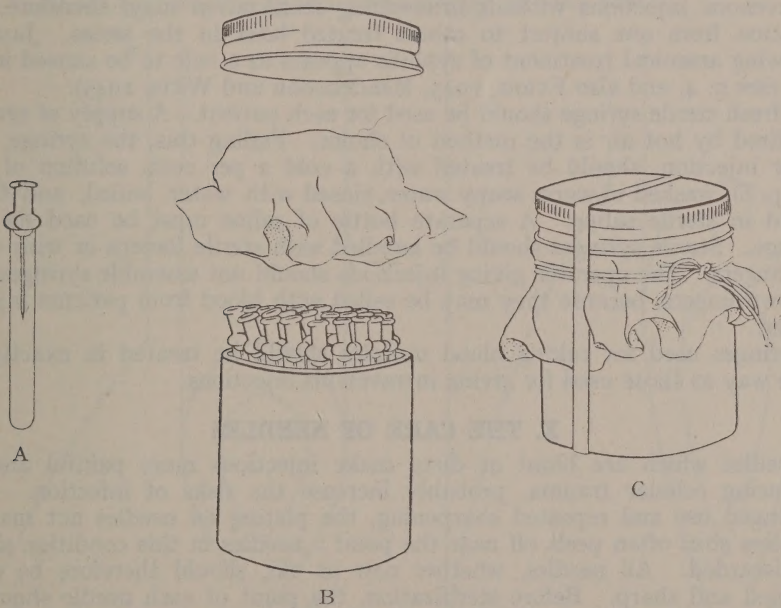


FIG. 5.—A shows the needle protected by glass tubing; B, the needles packed into their tin container; and C, the outfit after sterilization, ready for use.

tubes being nested in a tin which is covered before sterilization with two layers of lint and a metal lid. As each fresh needle is required, the cover is lifted just enough to expose a fresh needle, and the nozzle of the syringe is inserted

into the butt thereof. Gentle pressure downwards against the glass tube will fix the needle on to the syringe; it can then be more firmly secured by means of sterile forceps. The doctor who is injecting can easily fit his own needles as he requires them.

Used needles are taken off the syringe by means of forceps, and placed in a dish containing distilled water and a layer of cotton wool. If a needle sticks, it may be loosened by gently warming over a spirit flame. Needles are washed before they dry.

This method removes the need for any form of sterilization at the time of inoculation, and thereby simplifies the whole procedure. It has one disadvantage, in that it demands a large number of needles.

FILLING THE SYRINGE

This is the duty of one assistant. The rubber cap of the bottle must be sterilized with tincture of iodine or spirit each time it is used, or preferably kept covered with lint soaked in tincture of iodine or 70 per cent. alcohol. There is then no objection to using the same needle for filling the syringe and giving the injection. If a separate needle, of rather wider gauge, is used for filling the syringe and is left sticking into the rubber cap between the filling of successive syringes, it should be protected from aerial and droplet infection in the intervals, by covering it and the bottle with an inverted beaker or glass jar. A second needle, with a sterile cotton wool filter attached, may be pushed through the rubber cap as an air inlet.

IX. MASS INTRAVENOUS INJECTIONS

Mass intravenous injections, such as those given in a V.D. clinic, are attended by a peculiar danger. An intravenous injection entails aspiration of a small quantity of blood into the syringe. One syringe used for several consecutive intravenous injections without intervening sterilization may, therefore, pass infection from one subject to others treated later in the series. Jaundice following arsenical treatment of syphilis appears as a rule to be caused in this way (see p. 4, and also Evans, 1945, Mendelsohn and Witts, 1945).

A fresh sterile syringe should be used for each patient. A supply of syringes sterilized by hot air is the method of choice. Failing this, the syringe, after every injection, should be treated with a cold 2 per cent. solution of lysol (see p. 8), washed in warm soapy water, rinsed with water, boiled, and finally rinsed in sterile saline. A separate bottle of saline must be used for each syringe. Sterile syringes should be handled with sterile forceps or with clean, dry fingers. The operator giving injections should not assemble syringes with his own fingers, because they may be soiled with blood from patients injected earlier.

Syringes used for taking blood samples should be treated in exactly the same way as those used for giving intravenous injections.

X. THE CARE OF NEEDLES

Needles which are blunt or dirty make injections more painful and, by producing cellular trauma, probably increase the risks of infection. After prolonged use and repeated sharpening, the plating on needles not made of stainless steel often peels off near the point: needles in this condition should be discarded. All needles, whether new or old, should therefore be clean, polished and sharp. Before sterilization, the point of each needle should be carefully scrutinized with the aid of a hand lens. It should be straight and sharp, with no fold-over of the extreme tip. When drawn backwards between dry fingers, the needle point should feel perfectly smooth. Needles which show a blue-black colour as the result of over-heating have probably lost their temper and should not be used.

The polish of a needle may be restored by painting it with jewellers' rouge and water, allowing it to dry, and then rubbing it bright with a clean cloth. The stilette should be kept in the needle during polishing, to exclude rouge from the lumen. Afterwards, the needle should be rinsed in spirit to remove rouge, which otherwise may leave a mark on the skin.

Sharpening.—A new needle is not necessarily sharp. Inspect all needles before sterilization, and sharpen those that require it. An Arkansas slip-stone, with the edges slightly curved, is useful for this purpose (Fig. 6). Lubricate the stone with a drop of liquid paraffin or thin machine oil. Using either the flat or the curved (convex) surface of the stone, grind the bevel of the needle to a suitable shape. To do this, immobilize the needle by holding it, preferably attached to a syringe, bevelled face uppermost, against the bench or a block of wood in which a nick has been cut in which to lodge the needle. The bevel should be almost or quite flat.

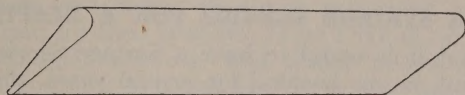


FIG. 6.—An Arkansas slip-stone, showing the convex top and the plane side.

When the bevel is satisfactory, and the point symmetrical, turn the needle through about 120° , and sharpen one cutting edge by a few touches with the *flat* surface of the stone on the rounded surface of the edge; repeat the process on the other cutting edge. The final appearance of the needle point should be as in Figure 7. The actual cutting edge of the needle should extend from the point to about half way along the bevelled edge on each side.

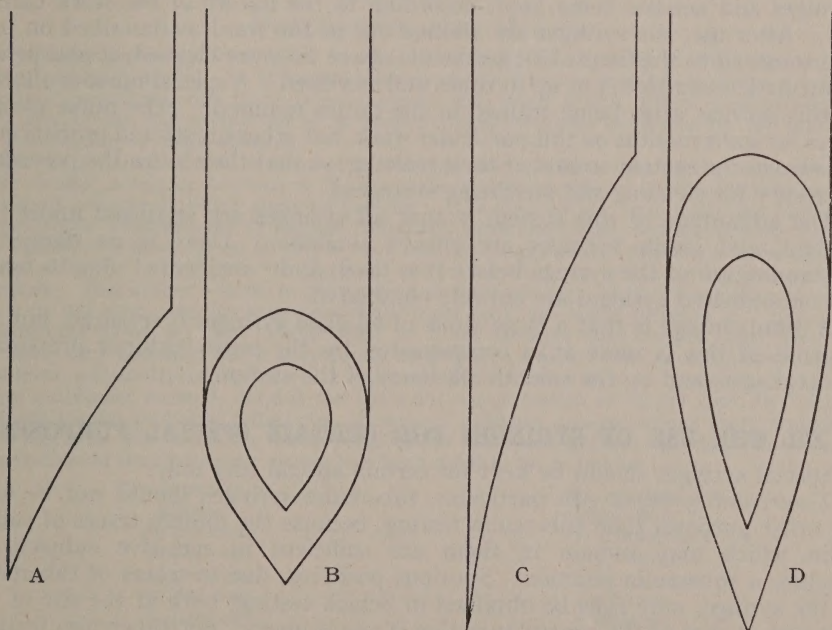


FIG. 7.—A and B represent the side and front views of a needle with a short bevel suitable for intradermal injection, and C and D corresponding views of a needle with a long bevel suitable for subcutaneous, intramuscular or intravenous injection.

Fairly long bevels are required for general use, but short, straight bevels are better for intradermal injection.

After sharpening, pass the stilette through the needle from mount to point, to make sure that metal fragments ("wire edges") are not projecting across the lumen, or lying free in it.

Examine the point with a hand lens or dissecting microscope, and detach any adhering or loose metal fragments with a dissecting needle. Clean the needle thoroughly after sharpening; metal dust or rust on the needle may leave a permanent mark at the site of injection.

Make sure that the inside of the needle mount is clean and smooth, or it will not fit properly on to the nozzle of the syringe. If large numbers of needles have to be serviced, much time and trouble can be saved by the use of a needle sharpening machine, which can be easily made from a power or treadle-driven polishing wheel.

XI. A SYRINGE SERVICE FOR A HOSPITAL

In a large hospital, it is useful to have a Syringe Service. Such a service has been in operation in one hospital for several years, and has proved very efficient and satisfactory. It is necessary, of course, to use entirely all-glass syringes with a standard type of fitting. Instead of each ward sterilizing its own syringes, there is a central department which deals with the cleaning, sterilization and issue of all syringes and needles. The department is in the charge of a Sister, whose duty it is to take care of all syringes and needles and see that they are properly sterilized. The syringes are assembled in tubes as described on p. 8, and needles of various sizes are put up as shown in Figs. 3 or 4. They are sterilized in a hot air oven in the laboratory of the hospital, under the supervision of the pathologist. The sterilized syringes and needles are issued by the Sister to each ward on demand, a suitable stock of both syringes and needles being kept, according to the nature of the work carried out. After use, the syringes are washed out in the ward as described on p. 8 and returned to the Central Department, where they are cleaned, re-sharpened, lubricated, assembled, put up in tubes and sterilized. A special nurse is allotted to this service, after being trained in the duties required. (The nurse usually stays for some months on this particular work, but other nurses and probationers are shown the system as part of their training, so that they know the procedure necessary for cleaning and sterilizing syringes.)

The advantage of this system is that all syringes are sterilized under one control, and sterile syringes are always available. There is no danger of contamination of the syringe before it is used, and "incidents" due to faulty or contaminated syringes are entirely eliminated.

A disadvantage is that a large stock of all-glass syringes is required, but the expense of this is more than compensated by the much reduced proportion of breakages, and by the smooth efficiency of the system.

XII. THE USE OF SYRINGES FOR CERTAIN SPECIAL PURPOSES

Special syringes should be kept for certain special uses only.

Tuberculin syringes.—In particular, tuberculin syringes should not be used for other purposes than tuberculin testing, because the minute traces of tuberculin which may remain in them are sufficient in sensitive subjects to produce a tuberculin reaction. Spurious positives, due to traces of tuberculin in the syringe, may thus be obtained in Schick testing, both at the site of the test and at that of the control injection if one is given. For tuberculin testing, special syringes should be kept for the test and for the control, and for different dilutions of tuberculin, and these should never be interchanged. It is advisable to keep syringes of different coloured glass for different tuberculin dilutions.

Schick and Dick Test syringes.—Similarly, for Schick and Dick testing, the test and the control syringes should be kept distinct and clearly marked, and should never be used for the collection of blood, administration of antitoxin or tuberculin tests.

Aspiration syringes.—As stated earlier, syringes used to aspirate infected material should never be used to give injections—not because the methods of sterilization recommended are untrustworthy, but because any simple precaution against occasional mistakes or accidents is worth taking.

Insulin syringes.—Insulin syringes, used by patients to administer their own insulin, are commonly disinfected with spirit. Since a syringe for this purpose is generally reserved for one patient only, and is used only to inject a sterile fluid, the risk of its contamination with pathogenic bacteria capable of damaging the patient is relatively small. For these reasons, and because of convenience, the use of spirit disinfection is considered justifiable for insulin syringes. It is an advantage if the syringe can be kept in spirit between injections. Patients who administer their own insulin should be instructed in the correct use of spirit as a disinfectant for their syringes, as set forth in Section VI above.

It is to be expected, however, that minor infections following insulin administration will continue to occur, as they very occasionally do now.

Adrenaline syringes.—The same conditions as in the case of insulin syringes apply to the syringes used by asthmatic patients to give themselves adrenaline. It is to be noted that in either instance the injection is liable to be painful if the syringe and the needle still contain traces of spirit when it is given.

Collection of Sera for Antitoxin Estimations.—Traces of antitoxin left in a syringe may not be destroyed by prolonged boiling. Syringes used for collecting sera for antitoxin estimations should therefore be subjected to the most thorough cleaning and sterilization possible.

APPENDIX A

DISINFECTION WITH ALCOHOL

1. *Factors governing disinfection by alcohol.*—Almost all reported studies refer to the action of ethyl alcohol. It is known that alcohols of higher molecular weight are more effective germicides, but there is no evidence that their action differs qualitatively, or that any of the major drawbacks of surgical spirit could be overcome by the addition or substitution of other alcohols.

The bactericidal action of alcohol is affected in a peculiar way by its *concentration*. Pure alcohol, acting on bacteria in the dry state, is without effect; for bactericidal action, a certain amount of water must be present. This observation, first made by Ahlfeld & Vahle (1896), was extended by Epstein (1897) and Minervini (1898), who respectively defined the optimum concentration as 50 per cent. and 50–70 per cent. The much more detailed study of Beyer (1912) gives the optimum as 70 per cent. by weight (76.5 per cent. by volume). This author's claim to have shown that 70 per cent. alcohol is superior to either 69 or 71 per cent., and his statement that 70 per cent. alcohol is 30 times as "strong" a disinfectant as 60 per cent. alcohol and 40 times stronger than 80 per cent., need not be taken very seriously, but it is evidently desirable to regulate the concentration at about this level, and to discard spirit which has undergone dilution in use. Gregersen (1915–16), using a different method, defined the optimum concentration as 75 per cent. by volume, and his results probably reflect the efficacy of different concentrations more truthfully than Beyer's. He found the times required for sterilizing garnets on which thick saline suspensions of *Staphylococcus aureus* had been dried to be as follows:—

Concentration of alcohol					Time required for disinfection
60 per cent.	..	..	..	..	1.5 minutes
70 per cent.	..	..	..	..	0.75 minutes
75 per cent.	..	..	..	..	0.63 minutes
80 per cent.	..	..	..	..	2 minutes
85 per cent.	..	..	..	..	5 minutes
90 per cent.	..	..	..	..	22 minutes
95 per cent.	..	..	..	..	270 minutes
99 per cent.	..	..	..	..	2–7 days
100 per cent.	..	..	..	..	more than 7 days

The *velocity* of disinfection by alcohol appears to depend to some extent on the *medium* in which it takes place. Watery suspensions of bacteria, as in Beyer's experiments, and even dried bacteria, as in Gregersen's, may be killed in less than one minute, if unprotected by a film of protein. When dried in other media they are more resistant, and disinfection times reported for broth cultures dried on silk threads are longer (Hansen, 1908), as are those for similar preparations of dried pus or mingled pus and blood (Salzwedel and Elsner, 1900). According to Eisenberg and Okolska (1913) and Neufeld and Schütz (1941), alcohol acts as well on large numbers of bacteria as on small. Among non-sporogenous bacteria none is particularly resistant to alcohol except yeasts and organisms found in vinegar; all bacteria associated with sepsis, whether Gram-positive or Gram-negative, possess the same order of susceptibility.

It has been well recognized, since Koch's demonstration of the fact in 1881, that alcohol is incapable of killing spores. No author has demonstrated this more strikingly than Bulloch (1928), who, in work on the disinfection of catgut, made cultures from old museum specimens bottled in spirit, and obtained sporogenous bacteria from specimens 39 and 46 years old; only a specimen bottled 122 years previously was sterile. It follows from this and from the conditions under which alcohol is handled commercially that surgical spirit may contain living bacterial spores; Kuhn and Dombrowsky (1932) cultivated them from about one half of 40 specimens examined. These were all aerobic bacilli, presumably non-pathogenic.

2. *Accidents due to contaminated spirit.*—Spirit in surgical use may undoubtedly be contaminated with spores of pathogenic bacteria; whether it is contaminated only during use or whether it may be supplied in this condition is not clear. There is a considerable literature, almost exclusively continental, on the occurrence of gas gangrene after therapeutic injections. Junghanns (1933) found 60 such cases in the literature, all but 4 of which were fatal, and Touraine (1936) adds 23 more. The infection usually occurs in already severely ill patients (pneumonia heading the list of primary conditions), and the list of drugs concerned is headed by adrenaline and caffeine. As Touraine remarks, "Presque tous les grands remèdes d'urgence y sont inscrits". Anti-syphilitic remedies and vaccines have never been recorded as producing it. In few cases has the source of the infection been traced, and since the commonest injection site concerned is the upper part of the thigh, the source may sometimes have been the patient's skin. In some cases, however, *Clostridium welchii*—the invariable cause when the nature of the infection is mentioned—has been cultivated from the syringe used or the spirit in which it had been kept. After a case of post-injection gas gangrene had occurred, Dimtza (1935) cultivated this organism from a syringe, a needle and four files used for ampoules, all of which had been kept in spirit. Jungmichel (1938) cultivated it from the spirit itself in similar circumstances, and Bittrolff (1938) from the syringe concerned, which had been kept in spirit. It is noteworthy in this connection that Nye and Mallory (1923) conclusively traced two successive cases of post-operative gas gangrene to scalpel blades "sterilized" in 70 per cent. spirit. Re-distillation or filtration of surgical spirit were the safeguards first proposed against these accidents, but in recent years German and Swiss authors have forsworn the use of spirit for syringes altogether, and have insisted on their sterilization by heat. Thus Habs (1938): "Der Alkohol muss schleunigst und endgültig aus der Desinfektion und Behandlung von Instrumenten verschwinden. Wir müssen fordern dass jede Spritze und Kanüle vor jedem Gebrauch durch Hitzeinwirkung sterilisiert wird." Regamey (1939), who obtained positive cultures from instruments kept for 30 days in 70 per cent. alcohol containing only about 100 spores per ml., advises autoclaving; Sobernheim and Mündel (1936) advise boiling in 2 per cent. sodium carbonate, to which they add a trace of formalin to compensate for the fact that water in Berne boils at 98°C. Sobernheim (1943), in a valuable review of the bactericidal properties of alcohol, approves of it for skin disinfection but condemns it for instruments.

3. *Evidence that spirit will not disinfect a contaminated syringe.*—The somewhat remote danger of producing gas gangrene is of less practical importance than the danger of transmitting septic and other common infections with a contaminated syringe which has been imperfectly sterilized. Reprehensible as the practice is, it is not unknown for practitioners to use the same syringe for aspirating an abscess and for injecting drugs or immunizing agents. Will spirit render such a syringe safe? A negative answer to this question receives its main support from the experiments of Bigger, Blacklock and Parish (1940), made during the investigation of a disaster in which children inoculated with T.A.F. developed tuberculous lesions at the site of injection. They introduced sputum containing streptococci into the lumen of a hypodermic needle, attached this needle to a syringe, and used it for withdrawing five lots of 5 ml. of T.A.F. from a bottle, washing out the syringe with both alcohol and ether after each emptying. The T.A.F. was expelled in 1 ml. amounts into tubes of glucose broth, and after the delivery of each ml. the needle was removed and dipped in alcohol. In spite of this repeated treatment with alcohol, both internal and external, every culture to the end of the series grew streptococci, thus indicating not only that the common practice of drawing spirit into a syringe will not disinfect it, but also that a little contamination in a syringe will go a long way.

4. *Original experiments made for the purpose of this Memorandum.*—All experiments were done at room temperature, and all with *Staphylococcus aureus* as the test organism (most with the same strain, "Corstin"). Except in the few instances when absolute alcohol was used, tests were made with industrial methylated spirit, which is equivalent to about 90 per cent. of alcohol, dilutions with distilled water or quarter-strength Ringer solution being prepared as required.

That 70 per cent. alcohol will kill this organism, even in an unfavourable medium, provided that the whole surface of the test object is exposed to its action, was shown as follows :—

- (1) Glass balls or garnets, dipped in a mixture of 9 parts of blood and 1 part of broth culture of *Staphylococcus* and dried, were sterilized in 5 minutes, but not in 2 minutes.
- (2) Glass rods, dipped in serum containing about 10 million staphylococci per ml. and dried, were sterilized in 10 minutes, but not in 5 minutes.
- (3) Capillary blood clots containing staphylococci were sterilized in 5 minutes in 5 out of 6 tests by absolute alcohol only. (The water content of the clot itself accounts for the necessity to use absolute alcohol in this form of test.)

Experiments with actual syringes were done in a variety of ways :—

- (4) Undiluted broth culture was drawn half way into a syringe and expelled. The syringe was filled with undiluted spirit and emptied 9 times in 15 minutes. Saline washings from the syringe and the syringe itself were then cultivated. Growth was obtained from both in each of 10 experiments.
- (5) The same experiment, with 1 in 1,000 culture and 70 per cent. alcohol.
Washings: 4 out of 8 cultures were positive.
Syringe cultures: 3 out of 8 were positive.
In identical tests with Pasteur pipettes, all cultures were sterile: i.e. the difficulty in sterilizing a syringe is due to its complex structure, with crevices which the disinfectant cannot penetrate.
- (6) Both "Record" and two-piece all-glass syringes were contaminated with 1 in 100 broth culture, and disinfected either by filling the syringe with spirit (several concentrations used) or by dis-assembling it and immersing the parts in spirit (time of exposure, five minutes in each case). Dis-assembled all-glass syringes were sterilized—but dis-assembled "Records" were not, and neither type was sterilized by filling alone.

That all-glass syringes can be disinfected if they are taken apart and immersed in spirit was further proved as follows :—

- (7) Syringes infected with serum containing about 10 million staphylococci per ml. were taken apart and dried. Barrels and plungers were separately immersed in 70 per cent. alcohol. Syringes were re-assembled at intervals, and tested for sterility by washing out with broth. They were sterile after 15 minutes, but not after 10 minutes.
- (8) 2 ml. all-glass syringes with needles were infected by filling with a mixture of two parts of broth culture and one part of blood: this was expelled and the syringes were dis-assembled and dried. Syringes were then re-assembled, filled with alcohol, and the needles and syringes separately immersed in alcohol. Broth cultures were made from both after 5, 10 and 15 minutes. Sixty per cent. alcohol sterilized both syringes and needles in each of four tests in all three time periods; 80 per cent. and 95 per cent. alcohol sometimes failed.
- (9) Experiment 8 was repeated with 60 per cent. alcohol which had been used for previous tests: 2 out of 16 needles and 7 out of 16 syringes showed growth. Similar unsatisfactory results were obtained with another sample of spirit, and with syringes infected with dried broth culture only, without blood. Using a fresh sample of alcohol, syringes infected in this way were sterilized in every one of 12 tests; one needle out of 12 gave a growth.

The conclusions reached from these experiments were—

- A. The common practice of attempting to disinfect a "Record" syringe by rinsing it with spirit (i.e. filling and expelling) is to be condemned. That it fails is doubtless due to the existence of crevices at the junction with the needle, at the junction of barrel and nozzle fitting, and in the slot of the piston ring and around the piston generally, which are not reached by the disinfectant. Even the immersion of the separate parts of such a syringe in spirit cannot be depended on to sterilize it.
- B. Presumably for similar reasons, rinsing cannot be trusted to sterilize an all-glass syringe, but immersion of the separate parts (barrel, piston and needle) in freshly decanted spirit of suitable strength—70 to 75 per cent. alcohol by volume—for at least five minutes, is satisfactory for destroying vegetative bacteria.

These conclusions are embodied in the recommendations made in Section VI of the Memorandum p. 13 above.

APPENDIX B

METHODS OF TESTING SYRINGES FOR LEAKAGE

Wellcome Foundation Method

A standard method for carrying out leakage tests is described in the British Standards Specification for "All-glass Hypodermic Syringes", No. B.S. 1263 (1945), referred to on p. 7 of this Memorandum. An alternative test is given below, which may be simpler to carry out in small laboratories where a source of air pressure is not available.

The following test was devised by Messrs. Tottem and Gebbett, of the Wellcome Physiological Research Laboratories, in collaboration with the Instrument Department of Burroughs Wellcome and Company. It is more severe than the simple "finger pressure test"; this often passes a 1 ml. "long" or "short" syringe that fails in actual use for intradermal injection.

The principle of the test is to apply a weight to the head of the piston of a syringe half filled with methylated spirit, the nozzle of the syringe being closed with a tested blind mount. Spirit facilitates drying of the syringe after testing.

Figure 8 illustrates the method. The barrel of the syringe is supported in a clamp on which the neck (rim) rests, acting as a stop. The clamp must not grip the barrel, since lateral compression of the syringe must be avoided. The purpose of the clamp is to keep the barrel in line with the thrust of the weight. When the syringe is filled with spirit, care must be taken not to introduce air bubbles. A weight is lowered on to the head of the piston and applied for a specified time. The leakage of spirit is read off from the excursion of the piston. There should be no leakage from the joint of the blind mount and nozzle.

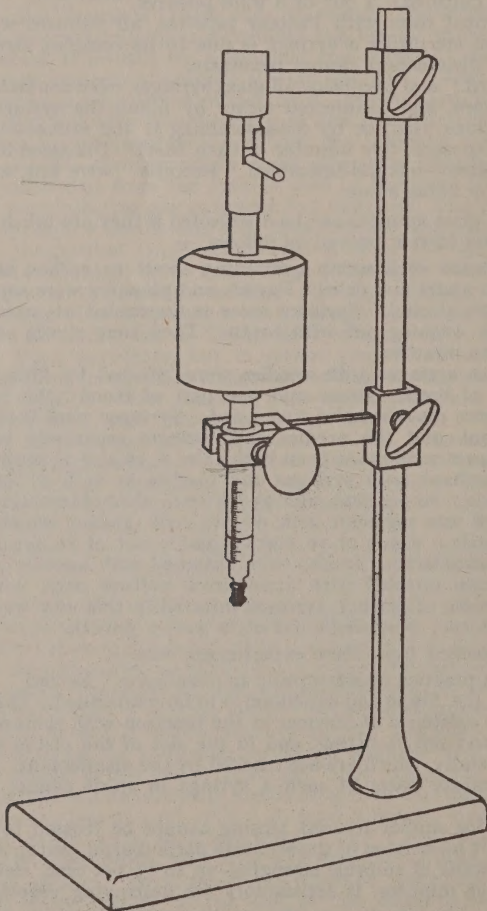


FIG. 8.—The Wellcome weight pressure method of testing syringes for leakage.

The weights to be applied, the times of application, and the allowable leakage of spirit have been determined empirically by trial on large numbers of syringes. They are shown below.

Capacity of Syringe	Weight to be applied, in gm.	Time of application, in minutes	Allowable leakage, measured by piston movement
1 ml. long type	1000	2	0.1 ml.
1 ml., all short types	1000	2	0.1 ml.
2 ml.	1000	4	0.2 ml.
3 ml., 5 ml., 10 ml. and 25 ml.	2000	4	0.5 ml.
20 minim; 40 minim; 60 minim	1000	4	3 minims

With syringes of good quality, such as were available in this country before the war, it appeared to be unnecessary to apply the test to each syringe with the piston in various positions relative to the graduations; a position half way between the two extremities of the barrel was employed as a routine, with completely satisfactory results.

Where syringes are of indifferent quality, it is advisable to test them with the piston in two positions, viz. (1) drawn out to the full extent of the graduations, and (2) half way along the graduated portion of the barrel.

The blind mounts should be re-tested on a standard gauge after every 100 syringes have been tested.

APPENDIX C

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